

REMARKS

Claims 2-6 are pending in this application. Applicants respectfully request reconsideration of the pending claims.

I. Supplemental Remarks

The following discussion supplements the discussion in the Amendment After Final Rejection filed April 17, 2008, and is directed to the rejection under 35 U.S.C. §103(a) as allegedly being unpatentable over U.S. Patent No. 5,702,540 ("Kubota") in view of U.S. Patent No. 4,191,599 ("Stickels").

The Patent Office has alleged that the time and temperature the nitrogen carrier is introduced is a result effective variable, and thus it allegedly would have been obvious to have optimized these variables and derived the process of claim 2.

However, during the April 15, 2008, interview, Examiner Zhu acknowledged that experimental trials demonstrating the criticality or unexpected results of the claim process compared to (1) a process in which the active nitrogen carrier is introduced at a temperature less than 400 °C and (2) a process in which the flow of the nitrogen carrier is continued after the charge reaches the carburizing temperature (i.e., carbonitriding as described in Kubota and Stickels), would overcome the allegation of obviousness.

Attached hereto is a Rule 132 Declaration ("Declaration"), demonstrating that the presently claimed method for under-pressure carburizing steel achieves unexpected results by restraining the austenite grain growth on the surface of the charge, while avoiding the formation of undesirable iron nitrides on the surface of the charge, when the active nitrogen carrier (e.g., ammonia) is (1) introduced into the vacuum furnace chamber during the preheating of the charge after the charge reaches at least 400°C (i.e., the lower limit) and (2) continuously introduced until the charge reaches the carburizing temperature, at which

point the active nitrogen carrier is stopped and the carbon carrier introduction is begun (i.e., the upper limit).

A. The Lower Limit

As described in the Declaration, Experiments 1-4 were conducted on three different low carbon steel grade charges comprised of C15, 16MnCr5 and 18CrNiMo7-6, respectively. Each of the low carbon steel grade charges were treated in a low-pressure vacuum furnace chamber at four different sets of process conditions labeled as Experiment 1, Experiment 2, Experiment 3 and Experiment 4.

Experiment 1 consisted of conventional under-pressure carburizing without any introduction of ammonia gas during preheating of the charge to the carburizing temperature. Experiment 2 consisted of under-pressure carburizing with the nitrogen carrier in the temperature interval of 20 °C - 400 °C (i.e., starting below the lower limit). Experiment 3 consisted of under-pressure carburizing with the nitrogen carrier in the temperature interval of 400 °C - 1000 °C (i.e., representative of the claimed process). Experiment 4 consisted of under-pressure carburizing with the nitrogen carrier in the temperature interval of 20 °C - 1000°C (i.e., starting below the lower limit and continuing until the upper limit).

As shown in Tables 2 and 3 and visually confirmed by Figures 1-3 of the Declaration, the steel charges that were subjected to Experiment 3 (i.e., the claimed method), as compared to the steel charges that were subjected to Experiment 1, Experiment 2 and Experiment 4, possessed both (1) the largest austenite grain size and (2) the finest austenite mean grain diameter.

Furthermore, as shown in Table 4 of the Declaration, the steel charges of Experiment 3 achieved the deepest case depth as compared to the steel charges of Experiment 1, Experiment 2 and Experiment 4.

As such, the experimental results demonstrate that the presently claimed method for under-pressure carburizing a steel charge mixture by introducing an active nitrogen carrier into the vacuum furnace chamber during the preheating of the charge after the charge reaches at least 400 °C unexpectedly restrained the austenite grain growth on the surface of steel charge.

B. The Upper Limit

As shown in Figure 4 of the Declaration, prenitriding followed by the introduction of the carbon carrier as in the claimed process permits nitrogen to be homogeneously distributed in the charge. This increases the nitrogen concentration over the original charge and thus inhibits austenite grain growth while maintaining a nitrogen concentration at the surface of the charge that is low enough to prevent the formation of disadvantageous iron nitrides.

Furthermore, two additional experiments (Experiment 7 and Experiment 8) were conducted. Experiment 7 consisted of subjecting a charge to a treatment by introducing a nitrogen carrier at a temperature of 400°C and continuously introducing the nitrogen carrier until the charge reached the carburizing temperature (980°C in this case), at which point the nitrogen carrier was stopped and the carbon carrier introduction started. The charge was then quenched and etched with Mi1Fe (Nital).

Experiment 8 was performed on a same type of charge and subjected to a treatment including introducing a nitrogen carrier at a temperature of 400°C. The nitrogen carrier was continuously introduced throughout the process. When the charge reached the carburizing temperature (980°C in this case), the nitrogen carrier was not stopped, and the carbon carrier introduction was started.

The light microscopy pictures shown as Figure 5(a) and Figure 5(b) in the Declaration represent the microstructure of the charge subjected to the treatment of Experiment 7 and Experiment 8, respectively.

As shown in Figure 5(b) of the Declaration, the large of amount of white fields, representing retained austenite on the surface of the charge, are caused by the high concentration of nitrogen (about 0.16%) at the charge's surface. This large amount of retained austenite decreases the hardness of the charge and thus results in a steel charge that is too soft. However, the charge of Figure 5(a) in Figure 5(b) has a lower surface concentration of nitrogen (about 0.02%) with fewer white fields representing retained austenite on the charge surface.

The charge derived by continuing the flow of a nitrogen carrier after the charge reaches a carburizing temperature (i.e., simultaneously with a carbon carrier) is shown in Figure 5(b) to have an increased nitrogen content, causing the disadvantageous stabilization of the retained austenite of the surface.

C. Conclusion

The present claims recitation of (1) introducing the active nitrogen carrier into the vacuum furnace chamber during the preheating of the charge after the charge reaches at least 400°C and (2) continuously introducing the nitrogen carrier until the charge reaches the carburizing temperature, at which point the active nitrogen carrier is stopped and the carbon carrier introduction is begun, cannot be considered to have been obvious from Kubota and Stickels. This is for all the reasons set forth in the April 17, 2008 Amendment After Final Rejection, and because the Declaration demonstrates that the claim process provides unexpectedly improved properties.

For all of the foregoing reasons, in addition to the reasons set forth in the April 17, 2008, Amendment After Final Rejection, withdrawal of this rejection under 35 U.S.C. §103(a) is respectfully requested.

II. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of claims 2-6 are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,



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Attachment:
Rule 132 Declaration

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